Piezoelectric Thin Films for Sensors, Actuators, and Energy Harvesting

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Abstract: Piezoelectric microelectromechanical systems (MEMS) offer the opportunity for high-sensitivity sensors and large displacement, low-voltage actuators. In particular, recent advances in the deposition of perovskite thin films point to a generation of MEMS devices capable of large displacements at complementary metal oxide semiconductor-compatible voltage levels. Moreover, if the devices are mounted in mechanically noisy environments, they also can be used for energy harvesting. Key to all of these applications is the ability to obtain high piezoelectric coefficients and retain these coefficients throughout the microfabrication process. This article will review the impact of composition, orientation, and microstructure on the piezoelectric properties of perovskite thin films such as $PbZr_{1-x}Ti_xO_3$ (PZT). Superior piezoelectric coefficients ($e_{31,f}$ of -18 C/m^2) are achieved in {001}-oriented $PbZr_{0.52}Ti_{0.48}O_3$ films with improved compositional homogeneity on Si substrates. The advent of such high piezoelectric responses in films opens up a wide variety of possible applications. A few examples of these, including low-voltage radio frequency MEMS switches and resonators, actuators for millimeter-scale robotics, droplet ejectors, energy scavengers for unattended sensors, and medical imaging transducers, will be discussed.